HOT-SPOTS ANALYSIS FOR CONSERVATION OF PLANT BIODIVERSITY IN THE MEDITERRANEAN BASIN[1]

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Abstract

Due to the increase of human impact on the world scale, there is an urgent need to identify the sectors of the greatest biodiversity that are also the most endangered. Examination of the plant biodiversity of the five regions with a mediterranean climate (SW Australia, the Cape region of South Africa, California, mediterranean Chile, and the Mediterranean basin) clearly demonstrates their key role in the world context. The delimitation and definition of 10 red alert areas or "hot-spots" situated in the Mediterranean basin and in Macaronesia are explained in detail. The 10 sectors identified are: the Canary Islands and Madeira, the High and Middle Atlas mountains, the Baetic-Rifan complex, the Maritime and Ligurian Alps, the Tyrrhenian Islands, Southern and Central Greece, Crete, Anatolia and Cyprus, the Syria-Lebanon-Israel area and, lastly, the Cyrenaic Mediterranean. There are two main centers of biodiversity in the Mediterranean basin: one in the west that includes the Iberian Peninsula and Morocco, and one in the East that includes Turkey and Greece. This analysis demonstrates the uniqueness and fragility of the island habitats.

Résumé

L'augmentation de l'impact anthropique à l'échelle du Globe nécessite d'identifier de façon urgente les secteurs de plus haute biodiversité, qui présentent également les plus grandes menaces. L'examen de la biodiversité végétale des cinq régions soumises au bioclimat méditerranéen (S.W. de l'Australie, région du Cap en Afrique du sud, Californie, Chili méditerranéen et bassin méditerranéen) souligne nettement leur rôle clé, par rapport au contexte mondial. La délimitation et la description de 10 zones-rouges, situées dans le bassin méditerranéen et en Macaronésie, sont développées. Les 10 secteurs identifiés sont: les îles Canaries et Madère, le Haut et le Moyen Atlas, le complexe bético-rifain, les Alpes maritimes et ligures, les îles tyrrhéniennes, le sud et le centre de la Grèce, la Crète, l'Anatolie et Chypre, l'ensemble Syrie-Liban-Israël, et, enfin la Cyrénaïque méditerranéenne. Deux pôles principaux de biodiversité existent sur le pourtour méditerranéen: un occidental qui comprend la péninsule ibérique et le Maroc, et un oriental englobant la Turquie et la Grèce. L'originalité des ensembles insulaires et leur fragilité se dégagent de cette analyse.

A few years ago, addressing increasing human impact on a world scale, the scientific community sounded an alarm, pointing out the harmful effects that would result from a decrease in biodiversity (e.g., Wilson, 1988; Lubchenco et al., 1991; Solbrig, 1992; Chauvet & Olivier, 1993; Levèque, 1994). This issue reached its pinnacle with the Convention on Biological Diversity, signed during the Rio Summit in June 1992, with the adoption of Agenda 21.

The accelerated decrease in the surface area of tropical forests (e.g., Myers, 1986; Forget, 1994) monopolized attention because this biome is seen as the world's principal pole of biodiversity (Gentry, 1982, 1988). Alpha diversity thus reaches record levels in Amazonia, where, in Ecuador—in a 1-ha[2] plot—Valencia et al. (1994) listed no less than 473 different species of phanerophytes with stems at least 5 cm in diameter, while Duivenvoorden (1994) observed 310 higher plants in a plot of 0.1 ha in Colombia.

In this context, identification of areas of major biodiversity is very desirable, considering that rates of extinction are unprecedented (Stanley, 1987). The current rate of disappearance of species is 1,000 to 10,000 times greater than that of major geological periods of mass extinction (Wilson, 1988). Myers (1988, 1990) developed an analytical methodology that enabled him to define red alert areas of biodiversity (known as "hot-spot areas"). A "hot-spot" is a sector with an exceptional concentration of species and a high rate of endemism

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that is in great danger of destruction. Species richness and endemism are two attributes of biodiversity commonly used in Conservation Biology because they reflect the complexity and uniqueness of ecosystems (Caldecott et al., 1996), and also because data for them is relatively easy to obtain on a global level. By limiting himself to the plant composition, Myers (1988) first defined 10 hot-spots in tropical forests, then four others in the same biome and four in the mediterranean bioclimate (SW Australia, the Cape region of South Africa, California, and part of Chile: Myers, 1990). This author had already emphasized the important role played by the circum-Mediterranean area as a reservoir of plant biodiversity. However, he cautiously refrained from regarding the entire Mediterranean basin as a hot-spot, arguing that it covers too large an area and that there is insufficient knowledge concerning certain parts of this area. Davis et al. (1994) recently drew up a list of 250 centers of plant diversity for the entire world, but this remarkable synthesis does not give details of all the Mediterranean hot-spots.

Therefore, more detailed analyses on the scale of the Mediterranean basin are necessary in order to try to establish a comparative study of the floristic richness and endemism of the various countries around the edge of the Mediterranean. This is possible for the total number of taxa that are present, i.e., 25,000 species (Quézel, 1985) or 30,000 species and subspecies (Greuter, 1991), but also for the endemic species (around 12,500). Even if these estimates are often imprecise, they can nevertheless provide precious information on both the location of the main centers of endemism and the situation of the areas of high biodiversity. They can also give an idea of the level of threat posed to any part of the basin, particularly after the work carried out in this direction by the International Union for Conservation of Nature (I.U.C.N., 1980, 1983).

Sites and Methods

Limits of the Mediterranean Region

The question of the limits of the Mediterranean region has been approached in various ways, including from the point of view of floristic methods, the analysis of vegetation structures, climatic interpretations, and, lastly, bioclimatic criteria. Although the validity of the Mediterranean isoclimatic area (Daget, 1977) is often accepted, it seems more realistic to use more traditional boundaries. Therefore we adopted (Figs. 1, 2) the limits drawn in the Natural Vegetation Map of the Countries of the Council of Europe (Conseil de l'Europe, 1987) and in the map of the vegetation of the eastern Mediterranean (Quézel & Barbero, 1985) for the countries of the northern Mediterranean, and the 100-mm isohyet, which remains a standard for defining the southern boundary between the mediterranean bioclimate and the Sahara, even if the 150-mm value would be locally more exact nowadays (Quézel & Barbero, 1993). The defined Mediterranean region thus covers an area of around 2,300,000 km^2 (Quézel, 1985). The archipelagos of the Canaries and Madeira have also been taken into account because, from a biogeographical viewpoint, these islands are now considered as a superprovince of the Canaries subregion, which is itself incorporated in the Mediterranean region (Rivas-Martinez et al., 1993).

Estimation of the Floristic Richness and Endemism of the Mediterranean Region

One of the main difficulties in estimating Mediterranean biodiversity is that there is rarely any direct correspondence between the biogeographical boundaries and the political boundaries of a state, while the floristic assessments are nearly always prepared according to the latter criterion. However, an attempt has been made by one of us (Quézel, 1985) and these results were later accepted by several authors, including Greuter (1995) and Heywood (1995). Precise assessments for the Turkish Mediterranean region still have to be established because its separation from the Irano-Touranian area is still a matter of debate; these communities share unquestionable biogeographical and bioclimatic affinities.

The inconsistent floristic knowledge of the different countries of the Mediterranean perimeter is also an obstacle. Some sectors—Italy, Turkey, Andalusia, Crete, and Corsica—are classified according to modern floras, while others still do not have complete floras (Morocco, Spain, the Balkans, Albania). The taxonomic levels also vary greatly, according to whether taxonomists adopt a restrictive approach or take the taxonomic breakdown further than is normally accepted. In addition to the recognition and fluctuating taxonomic status of some taxa, there is the problem of whether or not to take into account highly polymorphic groups, which are often apomictic, such as *Hieracium*, *Taraxacum*, *Achillea*, *Rosa*, *Rubus*, and *Limonium*. Thus, in Sardinia, no less than 23 endemic species of *Limonium* were recently described (Arrigoni, 1976–1991), i.e., 22% of the total local endemic flora. Furthermore, some assessments made take into account only the species, while others consider the species

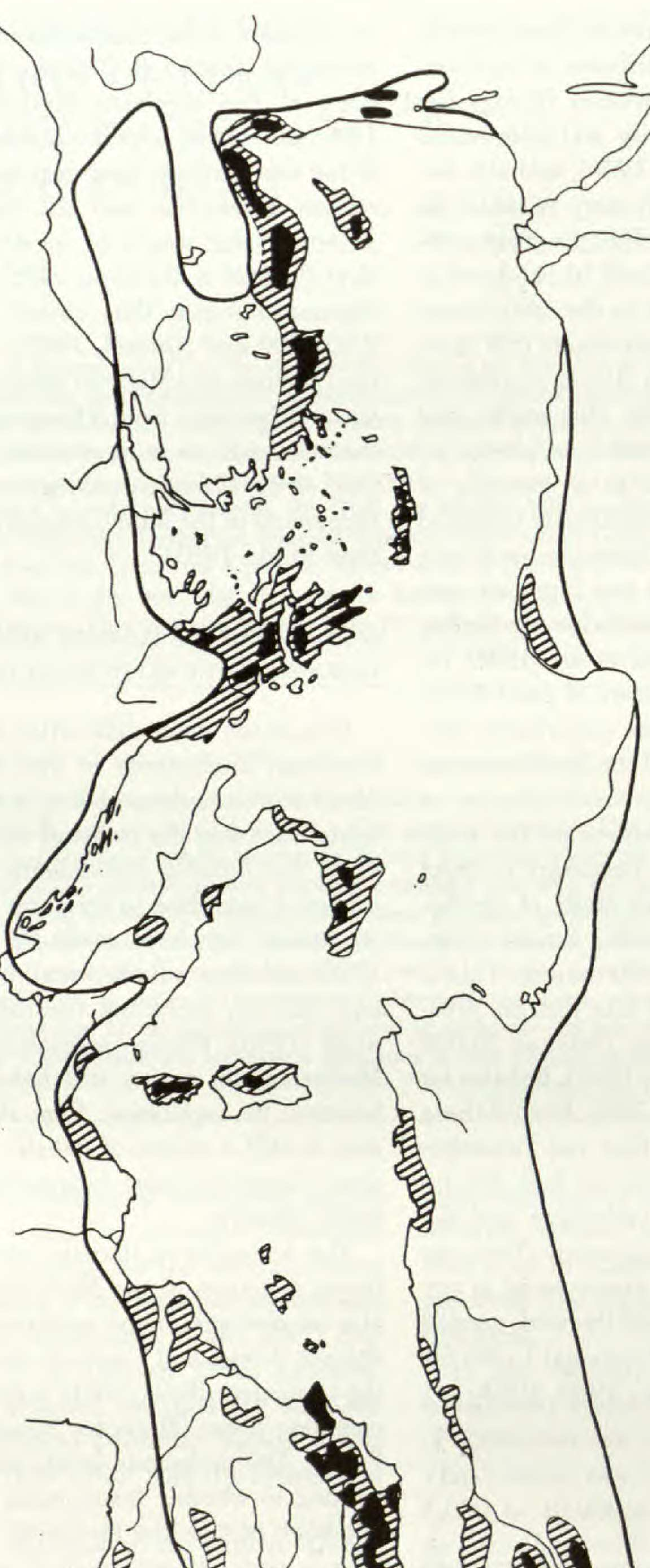

Figure 1. Biogeographical sectors with high incidences of plant endemism in Mediterranean basin.

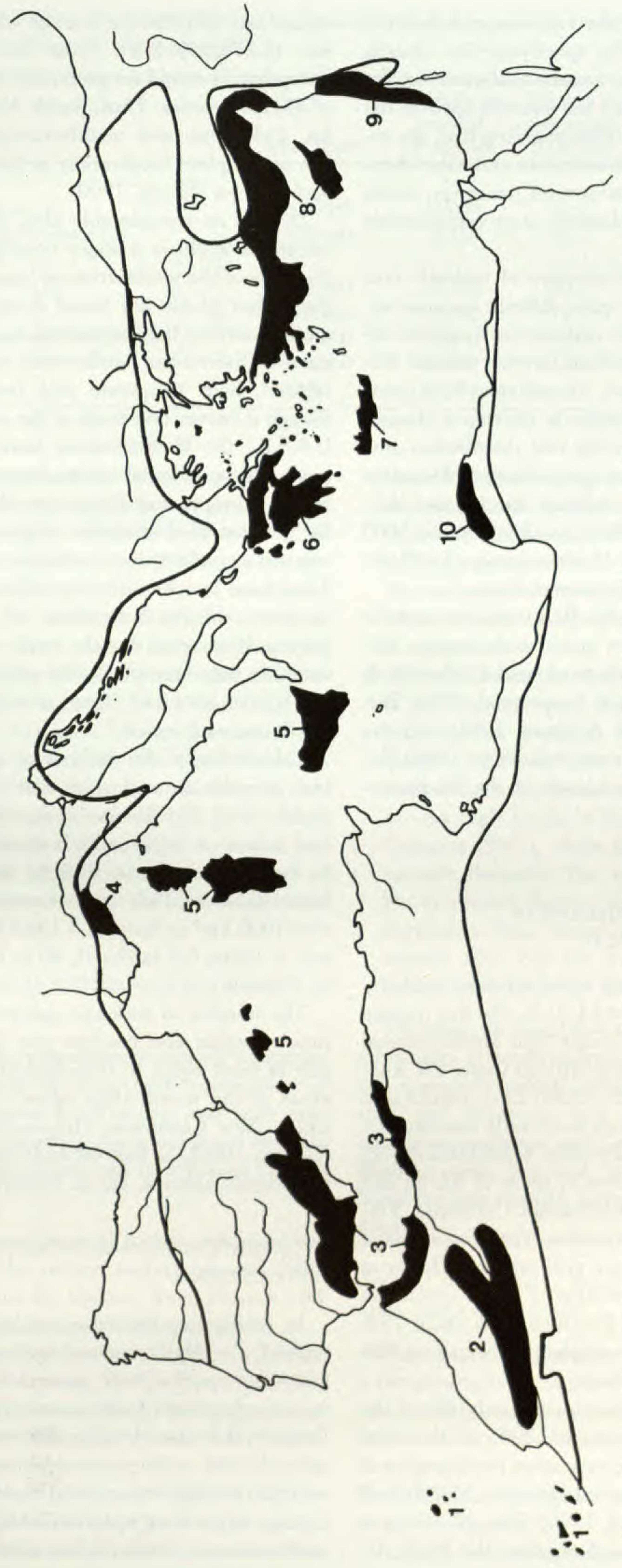

Figure 2. Mediterranean basin hot-spots. 1: Canaries and Madeiran archipelagos. 2: High and Middle Atlas Mountains. 3: Baetic-Rifan complex. 4: Maritime and Ligurian Alps. 5: Tyrrhenian islands. 6: Southern and Central Greece. 7: Crete. 8: Anatolia and Cyprus. 9: Syria–Lebanon–Israel. 10: Mediterranean Cyrenaic. The thick line defines the limits of the Mediterranean area.

and subspecies, or even the varieties and doubtful forms, without necessarily specifying this clearly. Since it is impossible to ensure uniformity of the results, we have indicated the sources used in the published tables, on the understanding that, the estimation of the number of endemics and subendemics (endemics common to several countries, sensu Pignatti, 1982), was problematic or even impossible in some cases.

The definition and delimitation of endemic taxa are often subjective and quite difficult because authors usually characterize endemic as a species restricted to a politically defined territory without biogeographical consideration. According to Strid (pers. comm.), biogeographers ought to develop a classification of endemics reflecting real distribution area and degree of ecological specialization. Mountain endemism includes the endemic species and subspecies regularly found above an altitude of ca. 1600 m, i.e., in the Mountain-Mediterranean, Oro-Mediterranean, and Alti-Mediterranean zones.

However, the data for the Mediterranean and the Macaronesian islands are much more precise, following recent well-documented works (Shmida & Werger, 1992; Gamisans & Jeanmonod, 1993; Turland et al., 1993; Press & Short, 1994) and the results of a recent conference (held in 1993) devoted to the flora of the islands of the Mediterranean.

Results

Biodiversity of the Mediterranean Biome in the World Context

According to the recent world overview study by Davis et al. (1986) for the I.U.C.N., the five regions with a mediterranean climate (the Mediterranean basin, California, the South African Cape, SW Australia, and mediterranean Chile) have remarkable biodiversity. Table 1 shows the results reworked by Myers (1990), particularly after Goldblatt's (1978) estimates for the Cape area or those of Raven and Axelrod (1978) for mediterranean California. Floristic patterns in mediterranean-type ecosystems of southwestern Australia are still unclear: Hobbs et al. (1995) made an estimation of 8000 species in the Southwest Botanical Province, with about 75% endemism; we keep this number but we stress that it is double Myers's estimate.

Thus, the mediterranean biome, only 2% of the world's surface area, contains 20% of the total world floristic range. The estimated total number of mediterranean plants varies between 45,000 and 60,000 species (Heywood, 1995). This difference is mainly due to the inclusion of either the South African Cape (90,000 km^2) or the whole of South Africa (2,573,000 km^2). From the biogeographical viewpoint, it would be preferable to take the value of 45,000 species. Thus, South Africa, SW Australia, California, and mediterranean Chile contain 8% of the plant biodiversity in 0.3% of the earth's surface area (Myers, 1990).

Despite its considerable area, the circum-Mediterranean world is a major contributor to the biodiversity of the mediterranean biome, since 10% of the higher plants are found there in 1.6% of the earth's surface. It is interesting to compare this circum-Mediterranean biodiversity with that of other regions, both temperate and tropical. Thus, although it covers one-tenth of the area of the former U.S.S.R., the Mediterranean basin contains 4,000 more species. Similar comparisons with the United States, Europe, and China are clearly in favor of the circum-Mediterranean region. Even certain tropical or subtropical countries such as India or Zaire have less biodiversity, while Brazil has twice as many species but covers an area four times greater. Note again that the whole of tropical Africa contains only around 30,000 plant species (Good, 1974) in an area four times greater than the circum-Mediterranean region.

Calculation of the number of species per 1000 km^2 provides an evaluation that is independent of surface area. For the mediterranean biome, we obtain values of between 95.5 species for 1000 km^2 in the Cape region to 10.8 for the Mediterranean basin (Table 1). This can be compared with: 1 species/1000 km^2 in Europe, 3.1 in China, 4.7 in Zaire and in India, 6.5 in Brazil, 40 in Colombia, and 90 in Panama.

The number of endemic species in the Mediterranean region also reaches very high values, usually at least equal to those found in most tropical areas of the world. Only islands such as Borneo, Cuba, New Caledonia, Hispaniola, New Zealand (Gentry, 1986), or high-altitude habitats are richer in endemic species, but in relatively limited areas.

Biodiversity of the World's Mediterranean Climate Regions

In relation to the other mediterranean climate regions, the Mediterranean basin has the greatest variety of species, both general and endemic, but in a much greater surface area (84% of the total). Despite the considerable differences in surface area, the two mediterranean climate regions of the northern hemisphere contain a virtually equal percentage of endemic species (Table 1). Furthermore, mediterranean California has more or less the same

Table 1. Plant biodiversity of the world's five mediterranean climate regions (1: Quézel, 1985; 2: Myers, 1990; 3: Hobbs et al., 1995; 4: Bond & Goldblatt, 1984).

	Areas (km^2)	Approximate number of species	Number of species per 1000 km^2	Endemic species Approximate number	%
North hemisphere					
Mediterranean basin (1)	2,300,000	25,000	10.8	12,500	50
California Floristic Province (2)	324,000	4,450	13.7	2,140	48
Austral hemisphere					
Mediterranean Chile (2)	140,000	2,900	20.7	1,450	50
S.W. Australia (3)	112,260	8,000	71	6,000	75
Cape Floristic Region (South Africa) (4)	90,000	8,600	95.5	5,860	68
Total	2,966,260	48,950	16.5	27,950	57
(%/World)	(2%)	(20%)			

surface area and general biodiversity as Morocco, but California is four times richer in strictly local endemics. However, the situation is reversed if, in Morocco, we consider all circum-Mediterranean endemics in the broad sense. The case of mediterranean regions in the southern hemisphere is even more remarkable, since, due to the long geographical isolation of these areas, the endemic richness reaches up to 70% in South Africa (the Cape region) and in SW Australia. The mediterranean region of the Cape, particularly the Cape Peninsula (Cowling et al., 1996), offers an extraordinarily rich flora: around 8600 species (Goldblatt, 1978; Bond & Goldblatt, 1984), including 5860 endemics, are found there, in a surface area equal to that of Greece, which makes it one of the most remarkable hot-spots in the world.

BIODIVERSITY OF THE MEDITERRANEAN BASIN AND MACARONESIA

Despite the above-mentioned various obstacles to the establishment of an accurate assessment of circum-Mediterranean biodiversity, and with certain reservations regarding the accuracy of the values quoted, certain points can be stressed (Tables 2 and 3):

—The Mediterranean parts of Turkey and Spain are found to have the richest variety (around 5000 species), followed by Greece, Italy, France, and Morocco (with more than 3000 species).

—The percentage of endemics is highest in Turkey (31%), then Morocco (21%), Spain (19%), Greece, Syria-Lebanon, and Italy. Greece is an interesting case: endemism is indeed high, particularly in the mountains, with 27% (Strid, 1993), and it would be even higher if all the Aegean perimeter were taken as a single entity. Similarly, evaluations that take into account the Ibero-Moroccan complex would at least double the number of endemics in these sectors. Furthermore, assessment of endemics by country or by biogeographical zone never or rarely includes the endemics of the entire Mediterranean basin, which clearly underestimates the indicated rate of endemism.

—The specific nature of the islands included within the Macaronesian complex, where, for historical reasons (Suning, 1979; Bramwell, 1985; Quézel, 1995) and due to the limited amount of competition, the percentage of endemism reaches very high levels in Madeira (26%) and in the Canaries (38%), while there is a rather limited specific richness. The same situation is found, but to a lesser degree, in the islands of the Mediterranean Sea, where endemism is generally around 10% but the overall range of flora is greater, with between 1500 and 2500 taxa.

Therefore, in simplified terms, there are two major centers of biodiversity in the Mediterranean basin: a western center, including the Iberian peninsula and Morocco, and an eastern pole that encompasses Turkey and Greece. The islands of the Mediterranean Sea and, to a greater degree, the Macaronesian islands, have a very high rate of endemism.

MAXIMAL BIODIVERSITY AREAS OF THE MEDITERRANEAN BASIN AND MACARONESIA

The circum-Mediterranean region is—according to the geographical zones of which it is composed—considerably varied in both its number of species and its number of endemics. Thus we should use biogeographical concepts in order to define circum-Mediterranean hot-spots, and political boundaries should be ignored.

Initially, we attempted to determine the biogeo-

Table 2. Plant biodiversity of the countries from the Mediterranean basin (islands excluded). The figures indicate the number of species, except for the values marked with an asterisk, which also include subspecies. Unless otherwise indicated, sources are: (a): Davis et al. (1986) and (b): Quézel (1985). Other sources: (c): original observations, (d): Greuter (1991), (e): Fennane & Ibn Tattou (1995), (f): Enriquez-Barroso & Gomez-Campo (1991), (g): Bartolo et al. (1977), (h): Boulos (1995), (i): Davis et al. (1994), (j): Davis (1988), (k): I.U.C.N. (1980), (l): Olivier et al. (1995), (m): Gomez-Campo et al. (1984).

Countries	Total areas (a) (km²)	Areas in Mediterranean bioclimate (b) (km²)	Approximate number of species		Number and approximate % of endemic plants	
			Total (a)	In Mediterranean region (b)	Number	%
Morocco	659,900	300,000	4,200	*3,800	*900 (e)	21.4
Algeria	2,381,000	300,000	3,150	2,700	*320 (d)	10.1
Tunisia	164,000	100,000	1,800	1,600	*39 (f)	2.1
Libya	1,759,000	100,000	1,600	1,400	*140 (g)	8.7
Egypt	1,000,000	15,000	2,060	1,100	61 (h)	3
Israel	20,700	10,000	2,200	2,000	*165 (i)	7.5
Jordan	97,600	10,000	2,200	1,800 (c)	145 (i)	6.6
Syria	185,000	50,000	3,100	2,600 (c)	*395 (i)	12.7
Lebanon	10,400	10,000	2,600	2,600	311 (i)	12
Turkey	779,000	480,000	8,600	5,000	2,651 (j)	30.8
Continental Greece	107,000	90,000	5,700	*4,000	*742 (i)	13
Albania	28,700	20,000	3,000	2,200	46 (k)	1.5
Former Yugoslavia	255,000	40,000	5,000	2,500	*320 (i)	6.4
Continental Italy	251,400	200,000	4,870 (c)	3,850 (c)	570 (c)	11.7
Continental France	549,600	50,000	4,800	3,200	180 (l)	3.7
Continental Spain	504,000	400,000	6,720 (d)	5,000	1,286 (d)	19.1
Portugal	91,000	70,000	2,600 (d)	2,500	114 (m)	4.4

Table 3. Plant biodiversity of the Mediterranean and Macaronesian islands. The figures indicate the numbers of species and subspecies, except for the values marked with an asterisk, which also include varieties. Rare and threatened taxa correspond to Ex, E, V, R, I, and K categories of I.U.C.N. Sources: (a): Davis et al. (1986), (b): Gamisans & Jeanmonod (1993), (c): Bocchieri (1995), (d): Raimondo et al. (1994), (e): Lanfranco (1995), (f): Turland et al. (1993), (g): Alziar (1995), (h): Schmida & Werger (1992), (i): Dalgaard (1994), (j): I.U.C.N. (1980), (k): Original observations, (l): Médail & Verlaque (1997), (m): Polunin (1987), (n): Mus (1995, modified), (o): Verlaque pers. comm., (p): Leon et al. (1985), (q): I.U.C.N. (1983).

	Area (km²)	Number of indigenous species and subspecies	Endemism in total flora s. str.	Endemism in total flora s.l.	% endemic species/flora		Rare and threatened taxa (endemics + non endemics)
					s. str.	s.l.	
Balearic Islands	5,014	1,450 (a)	94 (j)	180 (o)	6.5	12.4	59 (n)
Corsica	8,748	2,354 (b)	*130 (b)	270 (b)	5.5	11.5	90 (o)
Sardinia	24,090	2,054 (c)	106 (k)	200 (k)	5.2	9.7	39 (p)
Sicily	25,708	2,700 (d)	260 (o)	310 (o)	9.6	11.5	654 (d)
Malta	316	700 (e)	16 (e)	32 (k)	2.3	4.6	12 (p)
Crete (incl. Karpathos)	8,700	1,706 (f)	171 (f)	200 (m)	10	11.7	119 (q)
Cyprus	9,250	1,620 (g)	130 (g)	170 (g)	8	10.5	69 (p)
Canaries	7,273	1,582 (h)	504 (h)	600 (k)	31.8	37.9	432 (k)
Madeira Archipelago	796	670 (i)	113 (i)	175 (i)	16.9	26.1	137 (q)

graphical sectors where the rate of endemism is more than 20%; this figure is generally considered by biogeographers as delimiting a high level of endemism (Greuter, 1991; Quézel, 1995). Such percentages are not exceptional, particularly in the island and mountain areas, as demonstrated by Gomez-Campo et al. (1984) for the Iberian peninsula, where values of more than 50% are reached in the Baetican cordillera. All these zones were mentioned in Figure 1, where other areas can be distinguished, such as the Canary Islands and Madeira, the Middle and High Atlas ranges and the Rif in Morocco, the Sierra de Estrela in Portugal, as well as the upper mountain areas of Corsica, Sicily (Madonia and Etna), and probably Sardinia (Gennargentu mountain) in the central Mediterranean. Further to the east, endemism is very high in the upper mountain areas of southern Greece and of Crete, the Taurus ranges of Anatolia, the Troodos mountain of Cyprus, and the summits of the Lebanon and the Anti-Lebanon.

Other areas with a rate of endemism of around 10% deserve mention (Fig. 1): Sierra de Monchique in southern Portugal, Sierra de Gredos in the center-west of Spain, the hills of Teruel and Catalonia in the northwest, the Balearic Islands, the eastern Pyrenees, the Maritime and Ligurian Alps, the whole of Corsica and Sicily, some parts of the Italian peninsula (Pignatti, in litt. 1994), the coasts of Montenegro and Albania, the Pindus range and mount Athos peninsula in Greece, Cyprus and Crete considered together, the Mediterranean Cyrenaic, and the coastal Tell Atlas of Orania and Kabylia in Algeria.

Another way of estimating biodiversity is to identify zones of great floristic species richness, which, together with a study of endemism, would help to define hot-spots. In the present case, we selected geographical zones in their own right that cover a small or medium surface area, where the floristic variety is greater than 2000 species per 15,000 km^2. In the circum-Mediterranean region, the sectors that satisfy these criteria are certainly numerous, although they are sometimes difficult to define because of insufficient floristic knowledge for precise zones. However, the following can be included in this group: the Baetic-Rifan complex, the eastern Pyrenees, the Maritime and Ligurian Alps, Corsica and Sicily, the central Appennines and Calabria, the Dalmatian coast, Albania, Greece, Crete, the Amanus-Taurus region, the Syrian-Lebanese coast, Israel, and the coastal areas of Orania and Kabylia.

THREATS TO MEDITERRANEAN PLANT DIVERSITY

There are two very different situations in the circum-Mediterranean region relative to human impact (Barbero et al., 1990). The non-coastal zonal ecosystems of the northern part of the basin (France, Italy, and Greece) are markedly free of disturbance, and this leads to the extension of pre-forest and forest areas dominated by expansionist species. These include the *Pinus* species, which have remarkable ecological and biological plasticity and very high dissemination capacities (Barbero & Quézel, 1989). This extension of phanerophytes and also of chamaephytes tends to cause regression of formations of reduced vegetation cover, particularly the pastures, which are among the ecosystems that are the richest in Mediterranean taxa and in endemics. Therefore the collapse of the agro-sylvo-pastoral system of previous centuries causes major modifications to the structure and architecture of phytocenoses, with standardization of the flora and fauna. The Mediterranean elements tend to be replaced by medio-European species that are more ubiquitous. On the other hand, there is strong human pressure on a large part of the coastal and juxta-coastal areas, which poses a serious threat to halo-psammophile and palustral species. Island ecosystems are also very affected by the development of mass tourism.

The areas in the southern part of the Mediterranean basin (in particular North Africa) are subjected to the major impacts of the constant increases in population and in livestock, which totally destructure the ecosystems and the soils, causing strong erosive phenomena and very poor regeneration. This population explosion of the southern countries remains the major problem: their total population was 40 million in 1900, is now 290 million, and will probably reach 370 million by the year 2000 (Le Houérou, 1991).

Various recent works have tried to assess the risks incurred by the Mediterranean flora (Gomez-Campo, 1985; Quézel & Barbero, 1990; Ramade, 1990). The I.U.C.N. organization was a pioneer, and Leon et al. (1985) published a general assessment for all circum-Mediterranean flora and endemics (Table 4). Naturally, these results are open to question because they were established by various researchers who did not all have the same conception of the threats and the various categories proposed by I.U.C.N. to assess the risks. In addition, the exact situation of several species in several countries is unknown. However, according to this overview, 53% of the endemic species, i.e., 1529 taxa, are endangered (excluding Syria, Lebanon, and Turkey). One should be cautious before proposing values for the entire flora, but an analysis of the Algerian flora (Mathez et al., 1985) showed that almost 50% of the species had not been observed

Table 4. Threats affecting Mediterranean endemic plants, in countries where data are available (Leon et al., 1985, modified). Other sources: (a): Mus (1995), (b): Bramwell (1990), (c): Montmollin & Iatrou (1995), (d): Olivier et al. (1995), (e): Conti et al. (1992), (f): Raimondo et al. (1994).

Country or island	Extinct	Endangered and vulnerable	Rare or unknown
Albania	0	3	19
Algeria	1	53	80
Balearic Islands (a)	1	18	29
Canaries (b)	1	243	162
Corsica	1	32	3
Crete (c)	0	18	67
Cyprus	0	19	50
Egypt	2	18	48
France (d)	0	55	21
Greece	5	61	435
Israel	0	3	10
Italy (e)	0	98	108
Libya	0	20	42
Madeira	0	47	61
Morocco	0	4	238
Portugal	2	22	34
Sardinia	0	8	10
Sicily (f)	4	107	161
Spain	1	32	202
Tunisia	0	1	1
Former Yugoslavia	1	7	119

again for 20 years. The situation is also very worrying in Macaronesia, where more than 20% of the flora is endangered (I.U.C.N., 1983). Leon et al. (1985) listed only 16 species that have become extinct in the Mediterranean region since the beginning of the century. Recently, Greuter (1994) indicated that 37 species and subspecies of vascular plants of the Mediterranean area are presumed to be extinct. Nevertheless, these results are infinitely too optimistic to have any real significance, particularly for the countries of the southern Mediterranean. Furthermore, if we could really take into account the erosion of the different habitat types and of the number of populations of rare species, the situation would be undoubtedly worse that it seems.

Discussion

The results and analyses mentioned above can be used to identify sectors of the greatest general biodiversity with the greatest number of endemics that appear to be the most endangered, i.e., the "hot-spots" (Fig. 2) as defined by Myers (1988, 1990). We distinguished 10 sectors, which clearly fit Myers's definition, in the circum-Mediterranean region and we summarize the main threats to these hot-spots (Table 5). Some other zones (the Dalmatian coast, the eastern Pyrenees, and some parts of the Italian peninsula, or even Kabylia) could have been defined as hot-spots, but the data concerning them is too incomplete.

Archipelagos of the Canaries and Madeira

These islands of quite recent volcanic origin (5 to 7 million years: Carracedo, 1980) with a surface area of 8100 km^2, which are not connected to the continent, were apparently colonized by the long-distance transport of diaspora (Shmida & Werger, 1992). The initial absence of competition allowed strong adaptive radiation (Lems, 1960; Bramwell, 1975) and the establishment of a unique post-Miocene flora with a rich variety of endemics (Humphries, 1979; Bramwell, 1976, 1985; Quézel, 1995). Thus, of the total number of species 38% are endemic in the Canaries (Schmida & Werger, 1992) and 26% in Madeira (Dalgaard, 1994). But this unique flora is endangered (27% of the endemic flora in Madeira and 41% in the Canaries, according to the I.U.C.N., 1983). The Canaries archipelago is subjected to drastic human impact in its low-altitude zones by a considerable tourism infrastructure and the development of banana plantations. Infracanarian formations of cactoid *Euphorbia* and (to a greater extent) laurel woods have clearly regressed (Santos, 1990). Thus, the Gran Canaria laurisilva now covers less than 1% of its original area, while 90% of Tenerife's laurel woods have disappeared (Bramwell, 1990). Trees such as *Phoenix canariensis* Chab. and *Dracaena drago* (L.) L. are only found together in a residual position, or where they have been planted. Competition from allogenic plants (*Agave, Opuntia,* and *Acacia*) is also a serious problem. In the main island of the Madeira archipelago, the laurisilva covered some 60% of the total area but is now reduced to about 16% (10,000 ha) according to Press and Short (1994).

High and Middle Atlas Mountains

Covering an area of around 50,000 km^2, the High and Middle Atlas ranges are populated by numerous endemics—306 and 237, respectively—according to Enriquez-Barroso and Gomez-Campo (1991). The high rate of endemism is explained by the long isolation of these massifs and their high altitude. But, in addition to this mainly residual flora (Quézel, 1957), there is quite a large number of schizoendemics that demonstrate the role of the Atlas mountains in the neo-speciation process (Gal-

Table 5. Threats affecting the 10 hot-spots in the Mediterranean basin (+: low impact, ++: medium impact, +++: severe impact).

	Fire	Tourism	Overgrazing	Anarchic clear-cutting	Afforestation	Urbanization and industrialization	Land-abandonment, reforestation	Useful plants, crops	Bulbs crops	Competition by introduced plants
Canaries and Madeiran archipelagos		+++	+	+	++	++				++
High and Middle Atlas			+++	+++	+++			++		
Baetic-Rifan complex	++	+++	++		++	++		++		
Tyrrhenian islands	++	+++	+			+	+	++	+	+
Maritime and Ligurian Alps	++	+++				+++	++			+
Southern and Central Greece	++	+++	++		+	+	+	++		
Crete	++	+++	++		+	+		++	+	
Anatolia and Cyprus		+	++	+	++	+		++	+++	
Syria, Lebanon, Israel			+	++	++					
Mediterranean Cyrenaic	+		+++	+++	++					

land, 1988). This general region is greatly endangered by anthropization, particularly by overgrazing, land clearance, and anarchical deforestation that lead to desertification, even in the pastures of spiny xerophytes in clumps at high altitude. The balance was disturbed in the 1950s and, for example, land clearance of the Azilal Province alone now reaches 3000 to 5000 hectares per year, with annual erosion of between 5 and 10 m^3 per hectare (Estrade, 1988).

THE BAETIC-RIFAN COMPLEX

Andalusia and the Rif, linked together until the end of the Tertiary era, are grouped together in the same hot-spot because they have great floristic, ecological, and bioclimatic affinities. Around 75% of their total of 3500 species are common to the two regions (Valdès, 1991).

Rif and Tell Coastal Ranges of western Algeria. These two sectors of North Africa have a rich variety of endemics. In the Moroccan Rif range, there are at least 190 endemics, including 50 that are strictly limited to this zone (Enriquez-Barroso & Gomez-Campo, 1991). Unfortunately, this region is subjected to the relentless loss of natural vegetation, particularly due to the illegal growing of hashish. Between 1966 and 1986, the wooded areas and scrublands of the central-western Rif respectively decreased by an average of 42% (989 ha/year) and 38% (2852 ha/year), while cultivated land increased by 93% or 3847 ha/year (Boukil et al., 1987).

In Algeria, the Oranian and coastal sections of the Tell Atlas have, respectively, 91 and 89 endemics (Enriquez-Baroso & Gomez-Campo, 1991). The high rate of endemism reflects the Iberian and Moroccan influences (Quézel, 1964a). There is also strong human pressure, and habitats disappear at a rate that is difficult to estimate (Mathez et al., 1985).

Andalusia. This region of southeast Spain, 87,267 km^2 in area, is unquestionably one of the most important hot-spots of the Mediterranean basin. The complexity of the geologic and climatic history, but also the great diversity of habitats and substrata (including serpentines, dolomites, and gypsum), explain this high biodiversity (Valdès, 1993). Hernández-Bermejo et al. (1993) listed 484 strictly endemic taxa and 465 subendemics in Andalusia, and Gomez-Campo et al. (1984) obtained percentage of endemism greater than 50% in the Serrania de Ronda and in Sierra Nevada. The latter massif contains 177 endemics, including 66 that are exclusive (Gomez-Campo et al., 1984). Due to this exceptional biodiversity and the serious threats (600 rare taxa, including 68 in danger of extinction, according to Hernández-Bermejo et al., 1993), the local authorities have just recently put in place an integrated conservation plan (Hernández-Bermejo & Clemente-Muñoz, 1993) that aims to limit human activities in the mountain and coastal areas.

MARITIME AND LIGURIAN ALPS

The southwestern end of the alpine range is a noteworthy pole of biodiversity, since around 3100 species and subspecies, including almost 140 endemics, are found in this 9500 km² area (Médail & Verlaque, 1997). This high degree of richness is due to (a) the survival of ancient taxa (much of the region was not affected by the Würm periods of glaciation) facilitated by the diversity of habitats and ecological niches (with a strong altitudinal gradient in a small distance) and (b) the establishment of more recent taxa facilitated by the continuity of the alpine range. With the increase in population and the explosion of tourism along the entire coastline, the most serious dangers again threaten the species of the coast and low altitudes; one example is the disappearance of *Silene sericea* All., an endemic Tyrrhenian psammophilous species.

TYRRHENIAN ISLANDS

The Balearic Islands (except for the Pithyuses, which are biogeographically linked to the Iberian peninsula), Corsica, Sardinia, and Sicily are the remnants of areas that once belonged to the Protoligurian massif (Alvarez, 1976), a Hercynian formation that was fragmented in the Oligo-Miocene, causing migration of the Corso-Sardinian microplate. Only a part of Sicily (Peloritan massif) adjoined the Protoligurian massif in the south, but this island was included in this hot-spot for practical reasons. As a result, these islands have several floristic affinities, even if this Tertiary isolation contributed to the differentiation of neo-endemics that are specific to each area.

Balearic Islands. This archipelago has a relatively limited specific richness, with 180 endemic taxa of which 48 are endangered (Mus, 1995), but only 1 is known to have become extinct: *Lysimachia minoricensis* Rodr., which has, however, been conserved *ex situ.* Tourism and the changes of land use have seriously altered and modified the habitats, particularly coastal communities, low-altitude scrublands, and pine forests. According to a recent study (Mus & Mayol, 1993), 5% of the overall flora of the Balearics is seriously endangered.

Corsica. The flora and vegetation of this island are now well known, particularly after the works of Gamisans (1976–1978, 1991), Gamisans and Jeanmonod (1993), and Contandriopoulos (1962, 1990). In an area of 8748 km², 2354 indigenous taxa are found, with 270 endemics and subendemics, i.e., an 11.5% rate of endemism. The mountain flora includes 39% endemics. Although Corsica's flora seems to be relatively little endangered in the medium and upper altitudes, the situation is clearly more worrying in the coastal fringe, where three quarters of the endemics are endangered. It should be pointed out that 6 of them will probably become extinct, including 2 endemics specific to Corsica, as well as the extremely rare *Naufraga balearica* Constance & Cannon.

Sardinia. Although it is floristically rather poor (ca. 2050 taxa for 24,100 km²), Sardinia deserves to be included in this study because its well-documented endemism (Arrigoni, 1976–1991) is significant (106 endemics s. str.) and there are considerable threats. The low-altitude areas are again the most endangered, but conservation measures are still quite parsimonious, and there are only few reserves (Bocchieri, 1995).

Sicily. Due to its geographical position and contrasting paleogeographical origin, Sicily is an area of major botanical interest, with around 2700 taxa and 310 endemics and subendemics (Verlaque, pers. comm., according to Raimondo et al., 1994, modified). The flora of the hills of Madonia alone includes 50% of Sicily's species and 40 endemics (Brullo et al., 1995) in less than 2% of the island's area. The Etna district contains 21 endemics (Brullo et al., 1995). There are also endemic trees, which is uncommon in the Mediterranean basin: *Abies nebrodensis* (Lojac.) Mattei, which is seriously endangered, *Betula aetnensis* Raf., *Celtis aetnensis* Torn., *Pinus nigra* Arnold subsp. *laricio* Maire, and the recently discovered *Zelkova sicula* Di Pasquale, Garfi & Quézel. The human impact is mainly responsible for the probable extinction of 29 taxa, including 4 Sicilian endemics: *Allium permixtum* Guss., *Anthemis abrotanifolia* (Willd.) Guss., *Carduus rugulosus* Guss., and *Limonium catanense* (Tinbeo) Brullo (Brullo et al., 1995).

SOUTHERN AND CENTRAL GREECE

The Peloponnese, with an area of ca. 21,000 km², contains a total of 2400 species, including 300 Greek endemics, i.e., 12.5% endemism (Iatrou, 1986). Strid (1993) reported 26.5% orophile endemism in the Peloponnese, i.e., 143 endemics;

this reaches 38% if we include the Balkan endemics. The hills that contain the greatest biodiversity are the Taygetos, Chelmos, Parnon, and Killini mountains. The flora of the Peloponnese was affected mainly by north-south migrations and has strong links (130 endemics in common) with the central Sterea Ellas region, which were joined together only 900,000 years ago. In this hot-spot we have included the southern part of this region, from the Karpenision belt, where, in an area virtually the same as that of the Peloponnese, the rate of endemism and the floristic richness are comparable, particularly in the mountain massifs: Parnassos, Giona, Vardoussia, Panaetolicos, Dirphis; rupicolous endemism is more than 10% in almost all of this area, and reaches 20% locally (Quézel, 1964b).

When Greece joined the European Union, its economy swung from an agro-pastoral system to a productivist market economy, which will cause profound changes in the structure and architecture of the ecosystems, and therefore in biodiversity (Margaris, 1992).

CRETE

Crete is well documented from floristic (Turland et al., 1993) and phytoecological viewpoints (Barbero & Quézel, 1980; Zaffran, 1990). Spared by Quaternary glaciations and isolated for around 5 million years, this island has a unique flora, with 171 endemics out of a total of 1706 species and subspecies (Turland et al., 1993) in an area of 8700 km^2. The orophile flora of the three main massifs (Levka Ori, Psiloritis, and Dhikti) is very poor, but of the 217 taxa listed, 44% are endemic (Strid, 1993). In his analysis of the vegetation of Crete's mountains, Zaffran (1982) obtained comparable results: 25 to 40% of endemics for the rupicolous vegetation and 20 to 30% for stripped pastures.

The early colonization by man, about 8000 years ago, profoundly altered the natural balance, with exportation of timber and olives to Egypt between 2500 and 1500 B.C. (McNeely, 1994). Crete still bears the marks of thousands of years of intensive exploitation; forest patches are rare, while the scrublands have a lesser richness and floristic diversity.

ANATOLIA AND CYPRUS

Cyprus. The island of Cyprus, with an area of 9250 km^2, includes 1620 taxa with 170 endemics and subendemics (Alziar, 1995). The most interesting sector is the Troodos massif, where serpentinicole endemism is highly developed, with unique formations of *Cedrus brevifolia* (Hooker fil.) Dode and *Quercus alnifolia* Poech (Barbero & Quézel, 1979) and at least 45 local endemics. The entire island is subjected to major erosion (Tsiourtis, 1993), and mass tourism is developing rapidly on the south coast.

Anatolia. Southern Anatolia, especially the Taurus and Amanus areas, is one of the major centers of biodiversity and endemism in the circum-Mediterranean area. Biogeographical spectra in studies of the vegetation (Quézel, 1973) show that orophile endemism in the Taurus area reaches 20–40% in rupicolous associations, 10–20% in stripped pastures, and 35–70% in culminating screes, with a total of 250 endemics among the 650 species presented in the surveys. Davis et al. (1994) mentioned 2500 species including 250 Turkish endemics in the eastern part of the Taurus area and 3365 species in southwest Anatolia, including 675 Turkish endemics.

Even if the situation of the natural environments is better than in some other areas of the Mediterranean, the human impact is nevertheless perceptible in the overall Amanus/Taurus area. The numerous steppes are the result of continuous human activity, access routes, crop fires, and pasture fires. Land clearance over several centuries has mainly affected the forests of *Pinus nigra* Arnold subsp. *pallasiana* (Lamb.) Holmboe, *Cedrus libani* A. Richard, and *Quercus cerris* L. (Akman et al., 1991), but also the scrublands of endemic *Astragalus* (Demiriz & Baytop, 1985). However, one of the major problems is the intensive harvesting of mainly endemic bulb plants (Oldfield, 1990) for decorative and culinary purposes. Thus, according to Sezik (1989), 57 million tubers belonging to 38 species of orchids are picked annually and are used to prepare "salep," a milk drink.

SYRIA–LEBANON–ISRAEL

The summits of the Lebanon and the Anti-Lebanon ranges (Slenfe-Qammoua, Quriet es Sauda, Ehden Sannin, and Mount Hermon) and their peripheries are areas rich in endemics. One hundred species specific to mount Hermon and the Anti-Lebanon range have been counted (Zohary, 1973), while Auerbach and Shmida (1985) mentioned 47 endemic taxa on the coast of Israel, i.e., a rate of 27%. Nevertheless, the conflict in this region has seriously degraded the phytocenoses of the region, e.g., the formations of *Cedrus libani*. However, precise and recent data on the evolution of the natural environments are not available.

MEDITERRANEAN CYRENAIC

Even if the northern part of the Cyrenaic region does not have a rich flora (1300 species), it still contains no less than 81% of Libya's flora, in only 1.3% of the country's area. The rate of endemism is around 10%, with 137 endemic taxa including 84% of essentially Mediterranean origin (Bartolo et al., 1977, modified). The Djebel Akdhar plays a key role in the area's biodiversity, but the surface area of the natural environments of the "Green Mountain" has been reduced by half (or about 250,000 hectares) in half a century (El'Hamrouni, 1990). Tree-cutting, repeated fires, overgrazing, and mechanical land clearances in low altitudes to extend the orchards and vineyards have strongly altered this Mediterranean enclave.

CONCLUSION

Like the four other mediterranean areas of the world (Cody, 1986), the circum-Mediterranean region is one of the world's major centers for plant differentiation. The assessments mentioned above show that, particularly for the Old World, this region ranks among the most important areas of plant biodiversity. The circum-Mediterranean region alone contains as many species as Europe and Northern Africa combined. Similarly, its high level of endemism is remarkable, and is often equal to that of the world's tropical regions.

In the Mediterranean basin, this richness is not uniformly distributed and the areas of maximum biodiversity, particularly the 10 hot-spots defined here, mainly trace their origins to historical and paleogeographical factors (Pons & Quézel, 1985). The Mediterranean region is an area of refuge but also floral exchange and active speciation (Quézel, 1978, 1985, 1995). In the occidental part of the Mediterranean basin, the maximal biodiversity areas coincide notably (Verlaque et al., in press) with the "Protoligurian massif" and the "Orogenic Belt," which stretched from the Alps to the Baetic mountains during the Oligocene (Alvarez, 1976). The phenomena of stress (Stebbins, 1952), competition, and also the diversity of habitats, with a varied pedological component, explain the region's great richness and its endemism, which is particularly important in the high mountains and in the islands.

However, this biodiversity is now seriously endangered by radically different phenomena that affect the north and south of the basin. The southern countries are subjected to reckless human activity, with overexploitation by man and livestock in all available areas, following an exponential growth in population. On the northern perimeter, however, the virtual abandonment of the agro-sylvo-pastoral system is causing uniformization of the ecosystems and flora, linked to a general biological upsurge, while the coastal areas are ravaged by the spread of mass tourism. In order to counteract this erosion of the phanerogamic biodiversity, it would be necessary to refine the assessments presented in this work and to develop integrated conservation strategies for the identified hot-spots (Falk, 1990), both on the regional level (as has been started in Andalusia, the Balearics, and Corsica) and on national and international levels. We must also emphasize that threatened habitats in need of conservation (e.g., wetlands and coastal habitats) are not necessarily hot-spots of biodiversity. Thus, it is useful to make the distinction between a general need for conservation of endangered habitats, and a more specific need for conserving centers of plant richness and endemism through hot-spots.

In addition, it would be instructive to survey the hot-spots of other taxonomic groups besides plants in order to determine whether the various defined zones coincide. In Great Britain, Prendergast et al. (1993) did not find very close relationships between the hot-spots of the different groups, and this should be tested in the Mediterranean area.

Literature Cited

Akman, Y., P. Quézel, M. Barbero, O. Ketenoglu & M. Aydogu. 1991. La végétation des steppes, pelouses écorchées et à xérophytes épineux de l'Antitaurus dans la partie sud-ouest de l'Anatolie. Phytocoenologia 19: 391–428.

Alvarez, W. 1976. A former continuation of the Alps. Geol. Soc. Amer. Bull. 87: 91–96.

Alziar, G. 1995. La flore de Chypre. Ecol. Medit. 21: 47–52.

Arrigoni, P. V. 1976–1991. Le piante endemiche della Sardegna. Boll. Soc. Sarda Sci. Nat. 16–27.

Auerbach, M. & A. Shmida. 1985. Harmony among endemic littoral plants and adjacent floras in Israël. J. Biogeogr. 12: 175–187.

Barbero, M. & P. Quézel. 1979. Contribution à l'étude des groupements forestiers de Chypre. Doc. Phytosoc., nouv. ser. 4: 9–34 + 1 tab. h.-t.

——— & ———. 1980. La végétation forestière de Crète. Ecol. Medit. 5: 175–210.

——— & ———. 1989. Structures, architectures forestières à sclérophylles et prévention des incendies. Bull. Ecol. 20: 7–14.

———, G. Bonin, R. Loisel & P. Quézel. 1990. Changes and disturbances of forest ecosystems caused by human activities in the western part of the mediterranean bassin. Vegetatio 87: 151–173.

Bartolo, G., S. Brullo, A. Guglielmo & C. Scalia. 1977. Considerazioni fitogeografiche sugli endemismi della Cirenaica settentrionale. Archiv. Bot. Biogeogr. Ital. 53: 131–154.

Bocchieri, E. 1995. La connaissance et l'état de conservation de la flore de la Sardaigne. Ecol. Medit. 21: 71–81.

Bond, P. & P. Goldblatt. 1984. Plants of the Cape Flora. J. S. African Bot., Suppl. 13: 1–455.

Boukil, A. F., A. Blali & M. El Kassi. 1987. Evaluation et cartographie de la dégradation des forêts dans la zone nord. Ministère de l'Agriculture et de la Réforme Agraire, Centre régional de l'inventaire et des aménagements, Tetouan.

Boulos, L. 1995. Flora of Egypt. Checklist. Al Hadara Publ., Cairo.

Bramwell, D. 1975. Some morphological aspects of the adaptative radiation of Canary Islands *Echium* species. Anal. Inst. Bot. Cavanilles 32: 241–254.

———. 1976. The endemic flora of the Canary Islands; Distribution, Relationships and Phytogeography. Pp. 207–240 *in* G. Kunkel (editor), Biogeography and Ecology in the Canary Islands. W. Junk, The Hague.

———. 1985. Contribución a la biogeografía de las Islas Canarias. Bot. Macaronés., IV Ci. 14: 3–34.

———. 1990. Conserving biodiversity in the Canary Islands. Ann. Missouri Bot. Gard. 77: 28–37.

Brullo, S., P. Minissale & G. Spampinato. 1995. Considerazioni fitogeografiche sulla flora della Sicilia. Ecol. Medit. 21: 99–117.

Caldecott, J. O., M. D. Jenkins, T. H. Johnson & B. Groombridge. 1996. Priorities for conserving global species richness and endemism. Biodiv. Conserv. 5: 699–727.

Carracedo, J. C. 1980. Atlas básico de Canarias. Interinsular Canaria.

Chauvet, M. & L. Olivier. 1993. La biodiversité, enjeu planétaire—Préserver notre patrimoine génétique. Sang de la Terre, Paris.

Cody, M. L. 1986. Diversity, rarity, and conservation in mediterranean-climate regions. Pp. 122–152 *in* M. E. Soulé (editor), Conservation Biology. The Science of Scarcity and Diversity. Sinaveras Publ., Sunderland.

Conseil de l'Europe. 1987. Carte de la végétation naturelle des états membres des Communautés européennes et du Conseil de l'Europe. Publ. no. Eur. 10970, Commission des Communautés Européennes, Luxembourg.

Contandriopoulos, J. 1962. Recherches sur la flore endémique de la Corse et sur ses origines. Ann. Fac. Sci. Marseille 32: 1–354.

———. 1990. Spécificité de l'endémisme corse. *In*: Biogeographical aspects of insularity. Rome, 18–22 May 1987. Atti Accad. Naz. Lincei 85: 393–416.

Conti, F., A. Manzi & F. Pedrotti. 1992. Libro rosso delle piante d'Italia. WWF Italia, Roma.

Cowling, R. M., I. A. W. MacDonald & M. T. Simmons. 1996. The Cape Peninsula, South Africa: Physiographical, biological and historical background to an extraordinary hot-spot of biodiversity. Biodiv. Conserv. 5: 527–550.

Daget, P. 1977. Le bioclimat méditerranéen, caractères généraux, modes de caractérisation. Vegetatio 34: 1–20.

Dalgaard, V. 1994. Checklist of chromosome numbers counted in Madeiran flowering plants, with notes on polyploidy, life form, endemism and evolution. Nordic J. Bot. 14: 241–255.

Davis, P. 1988. Flora of Turkey and the east Aegean Islands supplement. Vol. 10. Edinburgh Univ. Press, Edinburgh.

Davis, S. D., V. H. Heywood & A. C. Hamilton. 1994. Centres of Plant Diversity. A Guide and Strategy for their Conservation. Volume 1. Europe, Africa, South West Asia and the Middle East. WWF & I.U.C.N. I.U.C.N. Publications Unit, Cambridge.

———, S. J. M. Droop, P. Gregerson, L. Henson, C. J. Leon, J. L. Villa-Lobos, H. Synge & J. Zantovska. 1986. Plants in danger. What do we know? I.U.C.N., Gland.

Demiriz, H. & T. Baytop. 1985. The Anatolian Peninsula. Pp. 113–121 *in* C. Gomez-Campo (editor), Plant Conservation in the Mediterranean area. Geobotany 7, W. Junk, Dordrecht, Boston, Lancaster.

Duivenvoorden, J. F. 1994. Vascular plant species counts in the rain forests of the middle Caqueta area, Colombian Amazonia. Biodiv. Conserv. 3: 685–715.

El'Hamrouni, A. 1990. Approche bioclimatique et biogéographique du Djebel Akhdar Cyrénaïque, Libye. Ecol. Medit. 16: 163–167.

Enriquez-Barroso, A. & C. Gomez-Campo. 1991. Les plantes endémiques de l'Afrique du Nord-Ouest: Algérie, Maroc et Tunisie. Bot. Chron. 10: 517–520.

Estrade, R. 1988. Les causes économiques de la dégradation du milieu naturel, le cas de la province d'Azilal. Séminaire natl. sur l'aménagement des bassins versants. Ministère de l'Agriculture et de la Réforme Agraire.

Falk, D. A. 1990. Integrated strategies for conserving plant genetic diversity. Ann. Missouri Bot. Gard. 77: 38–47.

Fennane, M. & M. Ibn Tattou. 1995. La flore rare des hautes montagnes marocaines. Pp. 199–205 *in* Actes des 6èmes Rencontres de l'A.R.P.E., Provence-Alpes-Côte d'Azur. Colloque scientifique international Bio-Mes, Gap.

Forget, P. M. 1994. Les forêts tropicales en sursis. La Recherche 270: 1154–1162.

Galland, N. 1988. Recherche sur l'origine de la flore orophile du Maroc. Etude caryologique et cytogéographique. Thèse Fac. Sci. Univ. Neuchâtel. Trav. Inst. Sci. Univ. Mohammed V, Sér. Bot. 35: 1–168.

Gamisans, J. 1976–1978. La végétation des montagnes corses. Phytocoenologia 34: 425–498; 41: 35–131; 42: 133–179; 43: 317–376; 44: 377–432.

———. 1991. La végétation de la Corse. *In*: D. Jeanmonod & H. M. Burdet (editors), Compléments au Prodrome de la Flore Corse. Conservatoire & Jardin botanique de Genève, Genève.

——— & D. Jeanmonod. 1993. Catalogue des plantes vasculaires de la Corse seconde édition. *In*: D. Jeanmonod & H. M. Burdet (editors), Compléments au Prodrome de la Flore Corse. Conservatoire & Jardin botanique de Genève, Genève.

Gentry, A. 1982. Patterns of neotropical plants species diversity. Evol. Biol. 15: 1–84.

———. 1986. Endemism in tropical versus temperate plant communities. Pp. 153–181 *in* M. E. Soulé (editor), Conservation Biology. The Science of Scarcity and Diversity. Sinaveras Publ., Sunderland.

———. 1988. Tree species richness of upper Amazonian forests. Proc. Natl. Acad. Sci. U.S.A. 85: 156–159.

Goldblatt, P. 1978. An analysis of the flora of Southern Africa: Its characteristics, relationships and origins. Ann. Missouri Bot. Gard. 65: 369–436.

Gomez-Campo, C. (Editor). 1985. Plant Conservation in the Mediterranean area. Geobotany 7, W. Junk, Dordrecht, Boston, Lancaster.

———, L. Bermudez-De-Castro, M. J. Cagiga & M. D. Sanchez-Yelamo. 1984. Endemism in the Iberian Peninsula and Balearic Islands. Webbia 38: 709–714.

Good, R., D'O. 1974. The Geography of Flowering Plants. 4th ed. Longman, London.
Greuter, W. 1991. Botanical diversity, endemism, rarity, and extinction in the Mediterranean area: An analysis based on the published volumes of Med-Checklist. Bot. Chron. 10: 63–79.
———. 1994. Extinction in Mediterranean areas. Philos. Trans., Ser. B 344: 41–46.
———. 1995. Origin and pecularities of Mediterranean island floras. Ecol. Medit. 21: 1–10.
Hernández-Bermejo, J. E. & M. Clemente-Muñoz. (Editors). 1993. Protección de la Flora en Andalucía. Junta de Andalucía.
———, A. Pujadas-Salva & M. Clemente-Muñoz. 1993. Catálogo general de las especies de recomendada protección en Andalucía endémicas, raras y amenazadas de extinción. Pp. 43–62 *in* J. E. Hernández-Bermejo & M. Clemente-Muñoz (editors), Protección de la Flora en Andalucía. Junta de Andalucía.
Heywood, V. H. 1995. The Mediterranean flora in the context of world biodiversity. Ecol. Medit. 21: 11–18.
Hobbs R. J., R. H. Groves, S. D. Hopper, R. J. Lambeck, B. B. Lamont, S. Lavorel, A. R. Main, J. D. Majer & D. A. Saunders. 1995. Function of biodiversity in the mediterranean-type ecosystems of southwestern Australia. Pp. 233–284 *in* G. W. Davis & D. M. Richardson (editors), Mediterranean-Type Ecosystems. The Function of Biodiversity. Ecological Studies, Vol. 109. Springer-Verlag, Berlin, Heidelberg.
Humphries, C. J. 1979. Endemism and evolution in Macaronesia. Pp. 171–199 *in* D. Bramwell (editor), Plants and Islands. Academic Press, London.
Iatrou, G. 1986. Simvoli sti meleti tou endemismou tis chloridas tis Peloponnissou. Thesis Inst. Bot. Univ. Patras.
I.U.C.N. 1980. First preliminary draft of the list of rare, threatened and endangered plants for the countries of North Africa and the Middle East. Mimeo, I.U.C.N., Kew.
———. Conservation Monitoring Centre. 1983. List of rare, threatened and endemic plants in Europe. 2nd ed. Nature and Environmental Series, 27. Council of Europe, Strasbourg.
Lanfranco, E. 1995. The Maltese flora and conservation. Ecol. Medit. 21: 165–168.
Le Houérou, H. N. 1991. La Méditerranée en l'an 2050: Impacts respectifs d'une éventuelle évolution climatique et de la démographie sur la végétation, les écosystèmes et l'utilisation des terres. La Météorologie: 4–37.
Lems, K. 1960. Botanical notes on the Canary Islands. II. The evolution of plant forms in the islands: *Aenium*. Ecology 41: 1–17.
Leon, C., G. Lucas & H. Synge. 1985. The value of information in saving threatened mediterranean plants. Pp. 177–196 *in* C. Gomez-Campo (editor), Plant Conservation in the Mediterranean area. Geobotany 7, W. Junk, Dordrecht, Boston, Lancaster.
Levêque, C. 1994. Le concept de biodiversité: de nouveaux regards sur la nature. Nature, Sciences, Sociétés 2: 243–254.
Lubchenco, L., A. M. Olson, L. R. Brubaker, S. R. Carpenter, M. M. Holland, S. P. Hubbell, S. A. Levin, J. A. MacMahon, P. A. Matson, J. M. Melillo, H. A. Mooney, C. H. Peterson, H. R. Pulliam, L. A. Real, P. J. Regal & P. G. Risser. 1991. The Sustainable Biosphere Initiative: An ecological research agenda. Ecology 72: 371–412.
Margaris, N. S. 1992. Régions de montagne en Grèce. Interprétation du déclin social et économique. Pp. 37–44 *in* Montagnes et forêts méditerranéennes. Agriculture et transformation des terres dans le bassin méditerranéen. Icalpe, Le Bourget-du-Lac.
Mathez, J., P. Quézel & C. Raynaud. 1985. The Maghreb countries. Pp. 141–157 *in* C. Gomez-Campo (editor), Plant Conservation in the Mediterranean area. Geobotany 7, W. Junk, Dordrecht, Boston, Lancaster.
McNeely, J. A. 1994. Lessons from the past: Forests and biodiversity. Biodiv. Conserv. 3: 3–20.
Médail, F. & R. Verlaque. 1997. Ecological characteristics and rarity of endemic plants from S.E. France and Corsica. Implications for biodiversity conservation. Biol. Conserv., in press.
Montmollin, B. & G. A. Iatrou. 1995. Connaissance et conservation de la flore de l'île de Crète. Ecol. Medit. 21: 173–194.
Mus, M. 1995. Conservation of flora in the Balearic Islands. Ecol. Medit. 21: 185–194.
——— & J. Mayol. 1993. Plans de conservacio dels vegetals amenaçats de Balears. I. Majorca. II. Menorca. III. Pitiüses. Documents tècnics de conservacio. Govern Balear, Conselleria d'Agricultura i Pesca, Direccio General D'Estructures Agraries i Medi Natural, Servei de Conservacio de la Naturalesa, Palma de Majorca.
Myers, N. 1986. Tropical deforestation and a mega-extinction. Pp. 394–409 *in* M. E. Soulé (editor), Conservation Biology. The Science of Scarcity and Diversity. Sinaveras Publ., Sunderland.
———. 1988. Threatened biotas: "Hot-Spots" in tropical forests. The Environmentalist 8: 187–208.
———. 1990. The biodiversity challenge: Expanded Hot-Spots analysis. The Environmentalist 10: 243–256.
Oldfield, S. 1990. The international trade in bulbs. T.R.A.F.F.I.C. (Int.) Bull. 11: 34–46.
Olivier, L., J. P. Galland, H. Maurin & J. P. Roux (Editors). 1995. Livre rouge de la flore menacée de France. Tome 1: Espèces prioritaires. Museum National d'Histoire Naturelle & Conservatoire Botanique National de Porquerolles, Paris.
Pignatti, S. 1982. Flora d'Italia. Edagricole, Bologna, 3 vol.
Polunin, O. 1987. Flowers of Greece and the Balkans, a Field Guide. Oxford Univ. Press, Oxford & New York.
Pons, A. & P. Quézel. 1985. The history of the flora and vegetation and past and present human disturbance in the mediterranean region. Pp. 25–43 *in* C. Gomez-Campo (editor), Plant Conservation in the Mediterranean Area. Geobotany 7, W. Junk, Dordrecht, Boston, Lancaster.
Prendergast, J. R., R. M. Quinn, J. H. Lawton, B. C. Eversham & D. W. Gibbons. 1993. Rare species, the coincidence of diversity hot-spots and conservation strategies. Nature 365: 335–337.
Press, J. R. & M. J. Short. 1994. Flora of Madeira. The Natural History Museum, HMSO, London.
Quézel, P. 1957. Peuplement végétal des hautes montagnes d'Afrique du Nord. Encycl. Biogéogr. Ecol., 10. Lechevalier, Paris.
———. 1964a. L'endémisme dans la flore de l'Algérie. C. R. Soc. Biogéogr. 361: 137–149.
———. 1964b. Végétation des hautes montagnes de Grèce méridionale. Vegetatio 12: 279–385.

———. 1973. Contribution à l'étude phytosociologique du Taurus. Phytocoenologia 1: 131–222.

———. 1978. Analysis of the flora of the mediterranean and saharian Africa. Ann. Missouri Bot. Gard. 65: 479–534.

———. 1985. Definition of the Mediterranean region and the origin of its flora. Pp. 9–24 *in* C. Gomez-Campo (editor), Plant Conservation in the Mediterranean Area. Geobotany 7, W. Junk, Dordrecht, Boston, Lancaster.

———. 1995. La flore du bassin méditerranéen: Origine, mise en place, endémisme. Ecol. Medit. 21: 19–39.

——— & M. Barbero. 1985. Carte de la végétation potentielle de la région méditerranéenne. Feuille no. 1: Méditerranée Orientale. C.N.R.S., Paris.

——— & ———. 1990. Les forêts méditerranéennes. Problèmes posés par leur signification historique, écologique et leur conservation. Acta Bot. Malac. 15: 145–178.

——— & ———. 1993. Variations climatiques au Sahara et en Afrique sèche depuis le Pliocène: Enseignements de la flore et de la végétation actuelles. Bull. Ecol. 24: 191–202.

Raimondo, F., L. Gianguzzi & V. Ilardi. 1994. Inventaria delle specie "a rischio" nella flora vascolare native della Sicilia. Quad. Bot. Ambientale Appl. 3: 65–132.

Ramade, F. 1990. Conservation des écosystèmes méditerranéens. Enjeux et perspectives. Les Fascicules du Plan Bleu, 3. P.N.U.E.-P.A.M. Economica, Paris.

Raven, P. R. & D. I. Axelrod. 1978. Origin and relationships of the California flora. Univ. California Publ. Bot. 72: 1–134.

Rivas-Martinez, S., W. Wildpret, T. E. Diaz, P. L. Perez De Paz, M. Del Arco & O. Rodriguez. 1993. Excursion guide. Outline vegetation of Tenerife Island Canary Islands. Itinera Geobotanica 7: 5–167.

Santos, A. 1990. Bosques de laurisilva en la region macaronésica. Nature and Environmental Series, 49. Council of Europe, Strasbourg.

Sezik, E. 1989. Turkish orchids and salep. Pp. 181–189 *in* Orchidées botaniques du monde entier. Soc. Fr. Orchidophilie, Paris.

Shmida, A. & M. J. A. Werger. 1992. Growth form diversity on the Canary Islands. Vegetatio 102: 183–199.

Solbrig, O. T. 1992. The IUBS-SCOPE-UNESCO program of research in biodiversity. Ecol. Appl. 2: 131–138.

Stanley, S. M. 1987. Extinctions. Freeman, Washington.

Stebbins, G. L. 1952. Aridity as stimulus to plant evolution. Amer. Naturalist 86: 33–44.

Strid, A. 1993. Phytogeographical aspects of the Greek mountain flora. Fragm. Florist. Geobot. Suppl. 2: 411–433.

Suning, P. 1979. Origins of the Macaronesian flora. Pp. 13–40 *in* D. Bramwell (editor), Plants and Islands. Academic Press, London.

Tsiourtis, N. 1993. Retenues et contrôle de la sédimentation à Chypre. Pp. 208–225 *in* Actes des 5èmes Rencontres de l'A.R.P.E., Provence-Alpes-Côte d'Azur.

Turland, N. J., L. Chilton & J. R. Press. 1993. Flora of the Cretan Area. Annotated Checklist and Atlas. The Natural History Museum, HMSO, London.

Valdès, B. 1991. Andalucía and the Rif. Floristic links and a common flora. Bot. Chron. 10: 117–124.

———. 1993. Origen y génesis de la flora Andaluza. Pp. 23–28 *in* J. E. Hernández-Bermejo & M. Clemente-Muñoz (editors), Protección de la Flora en Andalucía. Junta de Andalucía.

Valencia, R., H. Balslev & G. Paz y Mino. 1994. High tree alpha-diversity in Amazonian Ecuador. Biodiv. Conserv. 3: 21–28.

Verlaque, R., F. Médail, P. Quézel & J. F. Babinot. Endémisme végétal et paléogéographie dans le bassin méditerranéen. Geobios, in press.

Wilson, E. O. (Editor). 1988. Biodiversity. National Academic Press, Washington.

Zaffran, J. 1982. Contribution à la flore et à la végétation de la Crète. 2 vol. Publications Univ. Provence, Marseille.

———. 1990. Contributions à la flore et à la végétation de la Crète. Publications Univ. Provence, Aix-en-Provence.

Zohary, M. 1973. Geobotanical foundations of the Middle East. Gustav Fisher Verlag, Stuttgart.